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Acacia saligna as a supplementary feed for grazing desert sheep and goats

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SUMMARY

Acacia saligna, a leguminous tree, has a high crude protein content, remains green all year and can be grown in deserts using only runoff water. However, dry matter intake (DMI) by sheep and goats of *A. saligna* is low, presumably due to its high tannin content. It has been suggested that DMI could be increased by such methods as wilting of the forage and by neutralizing the negative effects of tannins by tannin-complexing agents. The purpose of this study was to determine DMI of supplementary *A. saligna* (phyllodes and small stems) by grazing sheep ($\sim$ 50 kg) and goats ($\sim$ 37 kg) when the animals were (1) offered wilted or fresh material (Expt 1); and (2) administered with polyethylene glycol (PEG), a tannin-binding agent (Expt 2). In this second experiment, there were three 14-day periods in which one group each of sheep and goats was on a regime of: No PEG–PEG–No PEG, whereas another group was on a regime of: No PEG–No PEG–PEG. In Expt 1, the DMI of *A. saligna* was statistically higher in goats than in sheep, but there was no difference in intake between fresh and wilted material. Average DMI of *A. saligna*, both fresh and wilted, was 124·1 g/day or 8·41 g/kg$^{0.75}$ per day for goats and 94·1 g/day or 5·05 g/kg$^{0.75}$ per day for sheep. Goats and sheep consuming fresh *A. saligna* gained more body mass than their respective controls; the difference was significantly greater in goats but not in sheep. In Expt 2, DMI of fresh *A. saligna* in the first period (before PEG) was 104·1 g/day or 7·16 g/kg$^{0.75}$ per day for goats and 84·8 g/day or 4·51 g/kg$^{0.75}$ per day for sheep. Administration of PEG during the second period resulted in an increase in DMI of 62% in goats and 83% in sheep. These animals maintained a high *A. saligna* intake in the third period when PEG was withdrawn. Goats and sheep that did not receive PEG in the second period had similar *A. saligna* intake as in the first period, but increased intake by 62% and 47%, respectively, with PEG in the third period. Overall, the two goat groups and two sheep groups consuming *A. saligna* lost less body mass than their respective controls; the difference was significantly less in sheep but not in goats. It was concluded that wilting *A. saligna* did not increase DMI. Administration of PEG increased *A. saligna* intake and the intake remained high after PEG was withdrawn. Offering *A. saligna* as a supplement had a positive effect on body mass change.

INTRODUCTION

Large tracts of arid and semi-arid lands in African and Middle Eastern countries are not cultivated but are used to raise livestock, mainly sheep and goats. However, because of low annual rainfall and, consequently, low feed availability, the raising of livestock in these areas is tenuous. Even in favourable rainfall years, animal performance is poor due to inadequate dietary protein and energy intake, particularly in the dry season. Moreover, in the event of drought, livestock mortality can be high without supplementary feed (Benjamin 1992).

In contrast to herbaceous vegetation, many trees and shrubs remain green all year, even during droughts. Consequently, it has been suggested that they could be useful as fodder for livestock in arid and semi-arid areas (Bohra 1980; Felker 1981; Seligman

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et al. 1989; Lefroy *et al.* 1992). Leguminous trees, in particular, have been examined as potential sources of fodder (Topps 1992) as they maintain a relatively high crude protein content throughout the year.

In general, however, limited success has been achieved with the use of trees and shrubs as livestock fodder because of low forage consumption. This is due mainly to the presence of anti-nutritional factors, notably tannins, which plants are stated to possess against herbivores (Zucker 1983; Kumar & Singh 1984; Robbins *et al.* 1987). Nonetheless, promising results were reported on the feeding of *Acacia saligna* (syn. *Acacia cyanophylla* Lindl.), a leguminous tree, to sheep and goats in Libya (Dumancic & Le Houerou 1981) and South Africa (Armstrong 1992). This is of particular interest as *A. saligna* is a fast growing tree used for firewood (NAS 1980) and grown in arid areas of Israel using only runoff water. However, low intakes, negative nitrogen balances and body mass losses by goats and sheep were reported when the animals were fed phyllodes of *A. saligna* as a sole diet (Degen *et al.* 1995, 1997).

Although *A. saligna* cannot serve as a sole food for goats and sheep, it may have potential as a dietary supplement because of its high crude protein content. It has been suggested that DMI of tannin-rich forage could be increased by such methods as wilting of the forage (Lowry 1990; Makkar 1993) and by neutralizing the negative effects of the tannins by tannin-complexing agents (Pritchard *et al.* 1992; Silanikove *et al.* 1997; Degen *et al.* 1998). The purpose of this study was to determine dry matter intake (DMI) of supplementary *A. saligna* by grazing sheep and goats when (1) offered wilted or fresh material and (2) administered with polyethylene glycol (PEG), a tannin-binding agent.

MATERIALS AND METHODS

Site of study and animals

The studies were carried out at Wadi Mashash, a research station 20 km south of Beer-Sheva (34° 47′ E, 31° 14′ N) in the Negev Desert, Israel. The area is considered semi-arid receiving a mean annual rainfall of 117 mm, all occurring in the winter. The natural pasture in the runoff area of the *wadi* is dominated by annual grasses with some shrubs and dwarf shrubs present. *A. saligna* trees are grown in limans using runoff water. In March of each year, following the first year of planting, all branches above 2 m are lopped off and the foliage below 2 m is harvested from the trees. Awassi sheep and cross-bred goats were raised by Bedouins as one flock at the site and, occasionally, these animals had browsed from *Acacia* trees.

The study was designed to minimize interference with the regular daily management of the animals. Herding was done by the Bedouin owners and supplements were given at a time when the flock was regularly brought to the encampment for watering and mid-day (11.00–14.00 h) resting. A corral was constructed near the Bedouin encampment for separating the animals into treatments and for weighing them.

Experiment 1: Intake of fresh v. *wilted* Acacia saligna

A total of 120 female sheep and 120 female goats were randomly selected from the flock. Each species was divided into three groups of 40 head each, with four subgroups per group.All animals had given birth and had weaned their young. Each animal was identified by numbering with a coloured ear-tag and allocated to one of three treatments according to *A. saligna* supplements, namely, (1) fresh, (2) wilted and (3) control – no supplement.

At 07.00–07.30 h (Israeli summer time), after watering, all animals were herded as one flock and after 15 min began grazing natural dry herbage. Gradually, towards 09.00 h, they progressed to plantations of widely placed trees in run-off catchment areas where shade and herbage were available. At 10.00–10.30 h, the flock was herded back to the encampment for watering and resting. At 11.00 h the goats and sheep were separated according to treatment groups and then were offered *A. saligna* supplement. Intake per animal per subgroup was calculated by dividing total intake by number of animals. At 14.00 h after watering, the animals were herded as one flock back to the grazing areas. At 18.00 h the animals were returned to the encampment for watering and were corralled overnight as one flock.

A. saligna was harvested daily by hand pollarding. These trees had been planted in 1990, first lopped in 1991 and pollarded in March–April 1994. Branches with a basal diameter of up to 10 mm were used and about 120 kg of fresh matter was collected. Of this amount, 40 kg was taken for immediate feeding to the sheep and goats (approximately 20 kg for each species) and the remainder was spread out for air drying for three days (wilted) for later feeding to the animals (approximately 10 kg for each species). The fresh and wilted *A. saligna* to be fed to the animals were collected into sacks and weighed on an electronic balance (± 20 g). A sample of *c.* 1 kg of each was collected daily for dry matter content determination.

The supplements were placed in feeding troughs before the animals were separated; separation of animals took about 15 minutes. Each morning at 07.00–07.30 h, refusals from the previous day were collected from the feeding troughs and from the ground, placed in sacks and weighed on the same balance as were the supplements offered. The amounts fed to each group were adjusted each day to ensure that there would be *ad libitum* intake, that is, at least 20% of edible material offered was left.

A 10-day adaptation period was allowed the animals during which time they were trained to be separated into their groups and were offered either fresh or wilted, or no *A. saligna* supplement. The trial began on 19 July 1994 when the animals were first weighed ($\pm 0{\cdot}1$ kg) after returning from the morning grazing and drinking water. Subsequently, the animals were weighed approximately every 14 days until 17 August 1994. As weighing took about 3 h, no supplements were offered that day.

Experiment 2: Effect of polyethylene glycol (PEG) on Acacia saligna *intake*

A total of 240 sheep and goats, all females that had given birth and weaned their offspring, were divided randomly into six equal groups. One group each of sheep and goats received neither *A. saligna* nor PEG and served as controls. Fresh *A. saligna* was offered to the other groups in three periods of 14 days each. One group, each of sheep and goats, underwent a treatment regime of No PEG–PEG–No PEG; and one group of each underwent a treatment regime of No PEG–No PEG–PEG. PEG was delivered in water by a solution of 1·6% (w/v), calculated so that each animal would receive about 40 g PEG/d.

Handling of the animals was as in Expt 1 except for the following differences: (1) animals were allowed to drink water *ad libitum* after being separated into their subgroups. Only after the animals had finished drinking was the *A. saligna* offered; (2) animals were weighed at the same time in the morning after returning from grazing but were weighed before drinking; and (3) refusals were separated into leaf and stems and samples of them, as well as composite samples, were analysed for composition.

Composition and metabolizable energy yield of Acacia saligna *offered and of refusals*

Dry matter composition of phyllodes, stems and composite samples were determined by drying in an oven at 50 °C until constant mass. This temperature was used in order to prevent tannins being inactivated directly or binding with fibre. Higher temperature of drying is not recommended for tannin-rich feedstuffs. In addition, we have compared drying samples at 50 °C and 80–90 °C and found no difference in dry matter content. Samples were analysed for nitrogen (N) content by the Kjeldahl method and for ash by burning at 550 °C (AOAC 1984). Crude protein was calculated as $6{\cdot}25 \times$ N. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined as described by Van Soest *et al.* (1991), applying a Fibertec System M6 (Tecator, Haganas, Sweden).

Total phenols were determined using the Folin–Ciocalteu method; total tannins with the Folin–Ciocalteu method in combination with insoluble polyvinylpyrrolidone (Makkar *et al.* 1993). Condensed tannins were determined using the butanol-HCl iron reagent (Porter *et al.* 1986).

Metabolizable energy yield of the phyllodes was estimated *in vitro* with the Hohenheimer Gas method (Menke *et al.* 1979). In this method the gas produced in anaerobic fermentation of substrate is used to predict the nutritive value. Rumen liquor and particulate matter were collected before morning feeding from two cattle fed on a roughage diet of mainly poor quality wheat straw and some lucerne hay; the liquor was homogenized, strained and filtered through glass wool. Incubation media was prepared as described by Menke *et al.* (1979). Samples, each of 200 mg DM, were incubated in triplicate in 100-ml calibrated glass syringes in which 30 ml of the incubation media was added. This was also done with samples in which 3 mg PEG was added. The glassware was kept at 39 °C and flushed with CO_2 before use and the mixture was kept stirred under CO_2 at 39 °C. Gas production, as determined by piston movement, was measured over 24 h after correcting for gas production due to rumen fluid alone.

Because of the possible detrimental effects of high tannin feed, the sheep were under constant veterinary care and observations by veterinarians from the Veterinary Hospital, Beer-Sheva. All animals were judged to be in good health throughout the study.

Statistical analyses

Analysis of variance (ANOVA) was used to analyse the data and was undertaken using the General Linear Modelling Procedure (SAS 1982). For analysis on body mass change, a repeated measures ANOVA was performed for each observation period. For DMI, subgroups were treated as replicates and measurements were done over days. The sources of error that were analysed included effects of treatments and animal species. A level of $P < 0{\cdot}05$ was chosen as the minimum for significance.

RESULTS

Experiment 1: Fresh v. *wilted* A. saligna

The DMI of *A. saligna* was higher in goats than in sheep, but there was no difference in DMI between fresh and wilted material (Table 1). Average DMI of *A. saligna*, both fresh and wilted, was 124·1 g/day or 8·41 g/kg$^{0{\cdot}75}$ per day for goats and 94·1 g/day or 5·05 g/kg$^{0{\cdot}75}$ per day for sheep. The goats and sheep

Table 1. *Mean body mass* (m_b), *change in body mass* (Δm_b) *and dry matter intake* (*DMI*) *of* Acacia saligna *in grazing sheep* (n = *40 per treatment*) *and goats* (n = *40 per treatment*) *consuming fresh, wilted and no* (*control*) *supplementary* A. saligna *over a 4-week period*

	Sheep			Goats				
	Control	Fresh	Wilted	Control	Fresh	Wilted	S.E.D.	*P*
m_b (kg)	49·4	49·9	49·6	38·7	35·2	37·7	1·80	*
Δm_b (kg/28 day)	1·58	2·00	1·62	0·41	2·04	0·89	0·42	*
DMI (g/day)		91·7	97·6		136·6	111·9	2·01	*
(g/kg$^{0·75}$ per day)		4·88	5·22		9·46	7·36	0·13	*

* $P < 0·05$

Table 2. *The effect of PEG administration* (*40 g/animal*) *on body mass* (*mb*) *change and on dry matter intake* (*DMI*) *of* Acacia saligna *offered as a supplementary feed to grazing sheep* (n = *40 per group*) *and goats* (n = *40 per group*) *in three periods of 14 days each*

		Treatment				DMI	
Group	Species	Acacia	PEG	m_b (kg)	m_b change (kg/14 days)	g/day	(g/kg$^{0·75}$ per day)
Period 1							
1	Sheep	+	−	50·0	−2·5	84·8	4·51
2		+	−	49·7	−2·4	91·7	4·90
Control		−	−	48·8	−3·4		
1	Goats	+	−	35·5	−2·3	104·1	7·16
2		+	−	37·3	−2·6	96·6	6·40
Control		−	−	38·4	−2·8		
S.E.D.				1·80	0·43	1·95	0·13
Significance				*	*	*	*
Period 2							
1	Sheep	+	+	48·2	−0·8	150·8	8·24
2		+	−	47·7	−1·0	94·4	5·22
Control		−	−	46·8	−0·6		
1	Goats	+	+	33·8	−1·0	162·8	11·61
2		+	−	35·9	−0·4	107·8	7·38
Control		−	−	36·9	−0·6		
S.E.D.				1·61	0·34	2·53	0·17
Significance				*	*	*	*
Period 3							
1	Sheep	+	−	48·2	0·7	169·1	9·25
2		+	+	47·5	0·6	138·9	7·68
Control		−	−	46·6	0·2		
1	Goats	+	−	33·1	−0·4	195·8	14·19
2		+	+	35·2	−1·1	173·1	11·98
Control		−	−	36·0	−1·3		
S.E.D.				1·62	0·36	2·50	0·19
Significance				*	*	*	*

* $P < 0·05$

consuming fresh *A. saligna* gained more body mass than controls; significantly so in goats but not in sheep. Change in body mass in animals eating wilted *A. saligna* fell in between controls and those consuming fresh *A. saligna* (Table 1).

Experiment 2: Polyethylene glycol (*PEG*) *on* Acacia saligna *intake*

Before PEG was administered in the first 14-day period, DMI of fresh *A. saligna* was 104·1 g/day or

Table 3. *The proportion of leaves in forage offered, in refusals and in forage consumed of supplementary* Acacia saligna *by grazing sheep and goats with and without PEG administration* (n = *12*)

	Sheep		Goats			
	No PEG	PEG	No PEG	PEG	S.E.D.	*P*
Forage offered (g/day)	232·5	244·8	231·5	247·5	13·88	n.s.
Proportion leaves	0·71	0·71	0·71	0·71	0·02	n.s.
Refusals (g/day)	93·8	95·0	88·0	92·5	9·72	n.s.
Proportion leaves	0·41	0·43	0·43	0·43	0·04	n.s.
Forage consumed (g/day)	139·5	149·6	143·3	155·0	15·64	*
Proportion leaves	0·92	0·89	0·89	0·88	0·04	n.s.

Table 4. *The chemical composition of stems, phyllodes and foliage* (*composite sample of stems and phyllodes*) *of* Acacia saligna *offered sheep and goats with and without PEG, and of their refusals* (n = *8*)

				Foliage refusals					
	Offered			Without PEG		With PEG			
	Stems	Phyllodes	Foliage	Goats	Sheep	Goats	Sheep	S.E.D.§	*P*
Crude protein (g/kg DM)	53·1	101·6	88·4	65·3	65·1	64·4	61·3	9·50	*
Ash (g/kg DM)	81·0	220·2	176·5	142·4	123·4	118·9	110·3	35·45	*
NDF (g/kg DM)	625·4	384·1	463·2	554·7	575·5	583·2	562·4	43·41	*
ADF (g/kg DM)	489·0	265·4	311·8	423·6	443·0	440·0	449·8	45·25	*
ADL (g/kg DM)	150·0	117·7	128·5	142·1	156·7	139·7	145·7	11·83	*
Gross energy (MJ/kg DM)	17·99	15·89	16·39	17·54	17·31	17·19	17·11	0·45	*
Total phenolics* (g/kg DM)	103·6	101·3	106·7	102·3	93·4	99·4	98·5	19·67	n.s.
Total tannins† (g/kg DM)	95·8	71·9	93·9	74·5	83·7	84·3	74·0	16·58	n.s.
Condensed tannins‡ (g/kg DM)	120·1	125·2	148·8	129·4	96·5	105·1	104·8	36·76	n.s.
ME without PEG (MJ/kg DM)	4·09	5·61	5·23	4·20	4·39	4·00	4·27	0·33	*
ME with PEG (MJ/kg DM)	5·33	6·77	6·75	5·63	5·33	5·49	5·30	0·29	*

DM, dry matter; NDF, neutral detergent fibre; ADF, acid detergent fibre; ADL, acid detergent lignin; ME, metabolizable energy.
* As tannic acid equivalent.
† As tannic acid equivalent.
‡ As leucocyanidin equivalent.
§ Refers to foliage offered and foliage refusals.

7·16 g/kg$^{0·75}$ per day for goats and 84·8 g/day or 4·51 g/kg$^{0·75}$ per day for sheep. Administration of PEG during the second period resulted in an increase in DMI of 62% in goats (7·16 to 11·61 g/kg$^{0·75}$ per day) and 83% in sheep (4·51 to 8·24 g/kg$^{0·75}$ per day). These animals maintained a high *A. saligna* intake in the third period when PEG was withdrawn. Goats and sheep that did not receive PEG in the second period had similar intakes to the first period, but increased intakes by 62% (7·38 to 11·98 g/kg$^{0·75}$ per day) and 47% (5·22 to 7·68 g/kg$^{0·75}$ per day), respectively, when administered with PEG in the third period (Table 2).

The ratio of phyllodes: stems, on a DM basis, that was offered the animals was 71:29. Ratio of phyllodes: stems of the refusals was the same for sheep and goats and for animals with and without PEG, averaging about 42:58. Therefore, both species selected phyllodes over stems, and phyllodes comprised about 0·88 to 0·92 of their diets (Table 3).

Gross energy content of stems was higher than that of phyllodes, but *in vitro* metabolizable energy (ME) yield was higher for phyllodes than for stems. PEG added to the forage improved digestibility and increased ME yield. Fibre content was higher and ash content lower in stems than in phyllodes. Total phenols and condensed tannins were similar in stems and leaves. Foliage presented to the animals had values between the stems and phyllodes. Because the animals consumed mainly phyllodes, gross energy was higher and digestibility and ME of refusals were lower than foliage offered. Fibre contents of refusals was higher than those of foliage offered (Table 4).

In general, there was a decrease in body mass in both sheep and goats over the study. There was a slight increase in body mass during the third period in sheep and a decrease in goats. Overall, the two goat groups and two sheep groups lost less body mass than their respective controls; the difference was significantly less in sheep but not so in goats (Table 4).

DISCUSSION

Fodder availability and quality are the main factors limiting livestock production in arid and semi-arid areas (Noy-Meir & Seligman 1979). This is so, even though the flora of these regions, including the Negev Desert, is often characterized by a relative abundance of semi-dwarf and dwarf shrubs (Noy-Meir & Seligman 1979). This situation has arisen because herbaceous species have been severely overgrazed relative to the shrubs and trees (Noy-Meir 1974).

Low consumption of trees and shrubs is the principal factor limiting their use as fodder for grazing livestock (Topps 1992). This is primarily due to defence mechanisms, notably tannins, which plants possess against grazing animals (Kumar & Singh 1984; Reed 1986; Robbins *et al.* 1987; Hagerman 1989; Makkar 1993). These tannins have wide-ranging effects that reduce consumption and digestibilities of the forage and that can be toxic to herbivores (Clausen *et al.* 1990; Garg *et al.* 1992; Murdiati *et al.* 1992). Daily DMI of *A. saligna* reached about 170 g per sheep and 196 g per goat. Assuming that *A. saligna* yields approximately 4·5 kJ metabolizable energy (ME) per g DM (Degen *et al.* 1995, 1997), this provided 765 kJ ME per day for sheep and 880 kJ ME per day for goats, or about 41 kJ/kg$^{0·75}$ per day and 59 kJ/kg$^{0·75}$ per day for sheep (50 kg) and goats (37 kg), respectively. Maintenance requirements for grazing Awassi sheep in the Negev is about 640 kJ/kg$^{0·75}$ per day (Benjamin *et al.* 1977) and so the *A. saligna* provided about 6·4% of maintenance requirements. If we assume that maintenance requirements per kg$^{0·75}$ in goats is about the same as in sheep, then the *A. saligna* provided about 9·2% of maintenance requirements for goats. Thus, *A. saligna* intake was up to about 10% of maintenance requirements in both species, yet it had a positive effect on body mass change.

The amount of tannins that herbivores tolerate differs among species (Robbins *et al.* 1987, 1991). Two main methods have been described in which herbivores can neutralize tannins and which can account for some of these among-species differences: (1) the secretion of tannin-binding proteins, mainly proline-proteins, in saliva (Mehansho *et al.* 1987) and (2) detoxification of tannins (Makkar 1993). Gut surfactants can also inhibit the precipitation of protein (Lindroth 1988). In general, browsers ingest more tannins, have saliva richer in proline (Austin *et al.* 1989) and are less affected by tannins than are grazers (Robbins *et al.* 1991). In addition, their parotid glands are larger than those of grazers (Hofmann 1989).

Goats consumed more *A. saligna* than sheep in Expt 1. Both sheep and goats do not produce proline-rich salivary proteins as a mechanism for neutralizing tannins (Austin *et al.* 1989; Distel & Provenza 1991). However, goats appear to defend against tannins to a better extent than do sheep by being able to detoxify tannins or their degraded products (Distel & Provenza 1991). Tannase has been identified in the rumen mucosa of goats (Begovic *et al.* 1978). They also appear to be able to digest *A. saligna* to a higher degree than sheep (Degen *et al.* 1995, 1997). The presence of salivary proteins, other than proline-rich proteins, having high affinity for tannins cannot be discounted (Austin *et al.* 1989; Makkar & Becker 1993, 1998).

It has been suggested that wilting can increase the intake of plants with toxic secondary compounds. Dumancic & Le Houerou (1980, 1981) and Ben Salem *et al.* (1997) reported that DMI of small ruminants fed *A. saligna* foliage as a supplement is improved if the foliage is fed after air drying rather than being fed immediately after harvesting. In addition, Ben Salem *et al.* (1997) reported large daily variation in intakes of *A. saligna* with peaks every 4 or 5 days and suggested that the decrease following the peak may be a consequence of tannin accumulation in the body. Apparently, the increase in intake in wilted forage occurs since enzymes that are able to degrade specific secondary compounds are present with the compounds in the same plant cells and with the disruption of the cell membranes, the reaction occurs (Lowry 1990). However, we did not find that wilting resulted in an increase in foliage intake with the sheep and goats consuming *A. saligna*. We also did not find a pattern of *A. saligna* intake either with or without PEG.

Administration of PEG resulted in a substantial increase in intake of *A. saligna* by both sheep and goats, and improved metabolizable energy yield. This was reported in other studies in which PEG was administered to small ruminants consuming tannin-rich foliage (Pritchard *et al.* 1992; Silanikove *et al.* 1997). Earlier, we had found that the intake of *A. saligna* increased when PEG was offered in drinking water to penned sheep and goats (Degen *et al.* 1998). Tannins have a higher affinity to PEG than to proteins and, as a consequence, administration of

PEG greatly reduces the formation of tannin-protein complexes. The tannin-PEG complex is relatively stable and irreversible over a wide pH range (Jones & Mangan 1977).

The higher *A. saligna* intake was maintained when PEG was withheld, which is similar to our laboratory findings. However, they are contrary to the findings of Silanikove *et al*. (1994) who fed carob leaves to sheep with and without PEG. These researchers found an increase in intake when PEG was offered but an immediate decrease in intake when PEG was withheld. There was no carry-over effect, that is, PEG had to be administered daily in order to maintain the increased intake. In our study, there was a carry-over effect.

It was concluded that wilting *A. saligna* did not increase DMI in sheep and goats. However, administration of PEG did increase *A. saligna* intake and the intake remained high after PEG was withdrawn. Provision of *A. saligna* had a positive effect on body mass change in the animals. These findings could have important management implications in the use of PEG to increase intake of tannin-rich fodder by livestock.

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